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Modern Gemini-Approach to Technology Development for Human Space Exploration

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In NASA's plan to put men on the moon, there were three sequential programs: Mercury, Gemini, and Apollo. The Gemini program was used to develop and integrate the technologies that would be necessary for the Apollo program to successfully put men on the moon. We would like to present an analogous modern approach that leverages legacy ISS hardware designs, and integrates developing new technologies into a flexible architecture This new architecture is scalable, sustainable, and can be used to establish human exploration infrastructure beyond low earth orbit and into deep space.

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Introduction

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- The Gemini program was used to develop and integrate the technologies that would be necessary for the Apollo program to successfully put men on the moon.
- We would like to present an analogous modern approach that leverages legacy ISS hardware designs, and integrates developing new technologies into a flexible architecture
- This new architecture is scalable, sustainable, and can be used to establish human exploration infrastructure beyond low earth orbit and into deep space.

Description of Approach

- This modern Gemini approach will make use of existing ISS module designs and subsystem designs, and integrate these with new technologies that are in development into a man-rated flight architecture.
- This architecture will use new high power generation systems coupled to high power electric propulsion systems to gain experience with these new technologies in a flight environment close to home.
- Components will be launched to the ISS on commercial, NASA, and possibly IP launch vehicles, in a similar cadence and scope to that used to assemble ISS itself.
- These components will be assembled at the ISS using the existing robotics, EVA, and IVA services where the exploration vehicle will be integrated and undergo commissioning.
- Once commissioned, the vehicle will depart ISS for GEO, and construction of the next vehicle at ISS can begin.

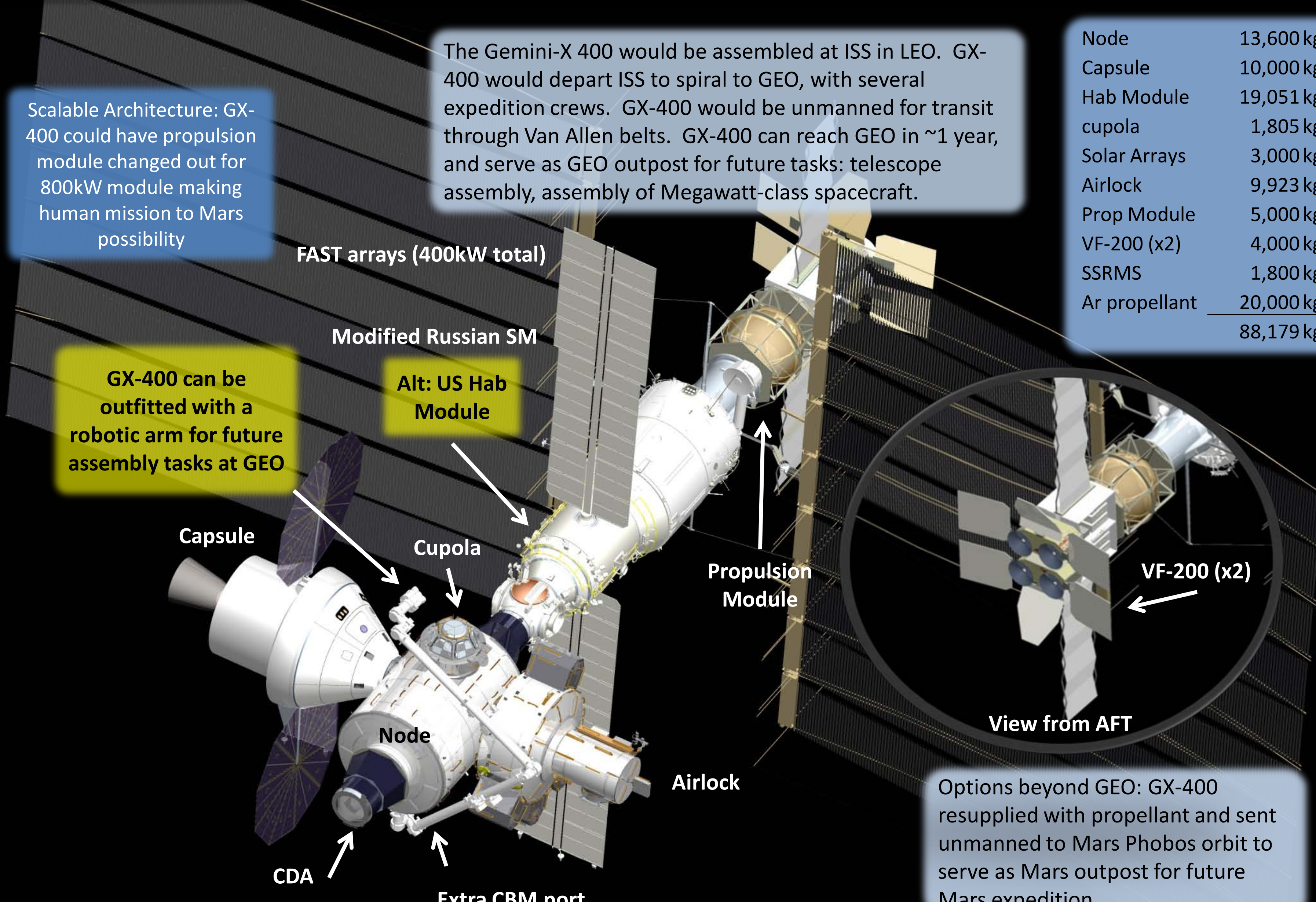
GEMINI-X 400 (GX-400)

The Gemini-X 400 would be assembled at ISS in LEO. GX-400 would depart ISS to spiral to GEO, with several expedition crews. GX-400 would be unmanned for transit through Van Allen belts. GX-400 can reach GEO in ~1 year, and serve as GEO outpost for future tasks: telescope assembly, assembly of Megawatt-class spacecraft.

Node	13,600 kg
Capsule	10,000 kg
Hab Module	19,051 kg
cupola	1,805 kg
Solar Arrays	3,000 kg
Airlock	9,923 kg
Prop Module	5,000 kg
VF-200 (x2)	4,000 kg
SSRMS	1,800 kg
Ar propellant	20,000 kg
	88,179 kg

Scalable Architecture: GX-400 could have propulsion module changed out for 800kW module making human mission to Mars possibility

GX-400 can be outfitted with a robotic arm for future assembly tasks at GEO



Options beyond GEO: GX-400 resupplied with propellant and sent unmanned to Mars Phobos orbit to serve as Mars outpost for future Mars expedition.

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GX-400 Concept of Operations

- Gemini-X 400 would be assembled at ISS in LEO.
  - Assembly at ISS makes use of existing space assets: robotics systems, EVA capability for nominal and off-nominal assembly tasks.
  - GX-400 assembly would occur with similar cadence to ISS assembly mode.
- GX-400 would depart ISS to spiral to GEO, with several expedition crews cycling 2-4 mos (using small capsule to rendezvous/depart).
- GX-400 would be unmanned for transit through Van Allen belts.
- GX-400 can reach GEO in ~1 year, and serve as GEO outpost.

GX-400 Extended Operations

- After departure of GX-400 Nº1, construction can begin on GX-400 Nº2 while GX-400 Nº1 transits to GEO.
- When GX-400 Nº1 reaches GEO, decision can be made to resupply propellant and send unmanned to Mars Phobos orbit to serve as outpost destination for future Mars expedition, transit time ~1.8 years.
- Once GX-400 Nº2 completed, it can start spiral to GEO to replace GX-400 Nº1 as GEO outpost:
  - serve as base of operations for future spacecraft assembly in GEO.
  - facilitate construction of large telescopes to be placed at Lagrange points.
  - be retrofitted into GX-800 (800kW prop module) configuration for manned mission to Mars and rendezvous with GX-400 Nº1.

GX-####, Scalable Architecture

- The GX-400 vehicle uses two VF-200 engines coupled to 400 kW of FAST arrays.
- The propulsion module can be increased to use four VF-200 engines coupled to 800 kW of FAST arrays (GX-800 configuration), which would reduce transit time from GEO to Mars Phobos from 1.8 years to ~0.9 years.
- This can be further grown in power to 1.2 MW, also reducing transit time.
- Conversely, the number of ISS-derived modules/components can be increased to create a larger living space and more capability to be used once the vehicle arrives at its final destination.
  - For example, the baseline GX-400 conceptual design could have another node with several additional modules suited to mission needs.
  - This vehicle can be transited manned or unmanned to its final destination.

Conclusions

- Using this modern Gemini approach to human exploration gets NASA practical experience with these new technologies sooner rather than later, and avoids a step-function roadmap.
  - It makes use of the United States' significant investment in the ISS, and encourages international participation in the effort.
  - Scalable approach allows for a healthy combination of evolutionary and *revolutionary*.
  - It will most certainly inspire the next generation of explorers.
- In the 1960's NASA did not wait for the entire Apollo architecture to mature before embarking on meaningful manned spaceflight missions.
  - Rather, 1960's NASA engaged in the age-old approach adapted from the aviation industry – build a little, test a little.
- Today, we should take heed of this lesson as we assemble our technology roadmaps and develop a portfolio with intermediate manned mission concepts that make use of these developing technologies as soon as possible.
- Most importantly, this modern Gemini approach briefly detailed here implements a frequency and scope of effort very similar to that undertaken since the beginning of assembly of the ISS, meaning it will be sustainable and affordable.

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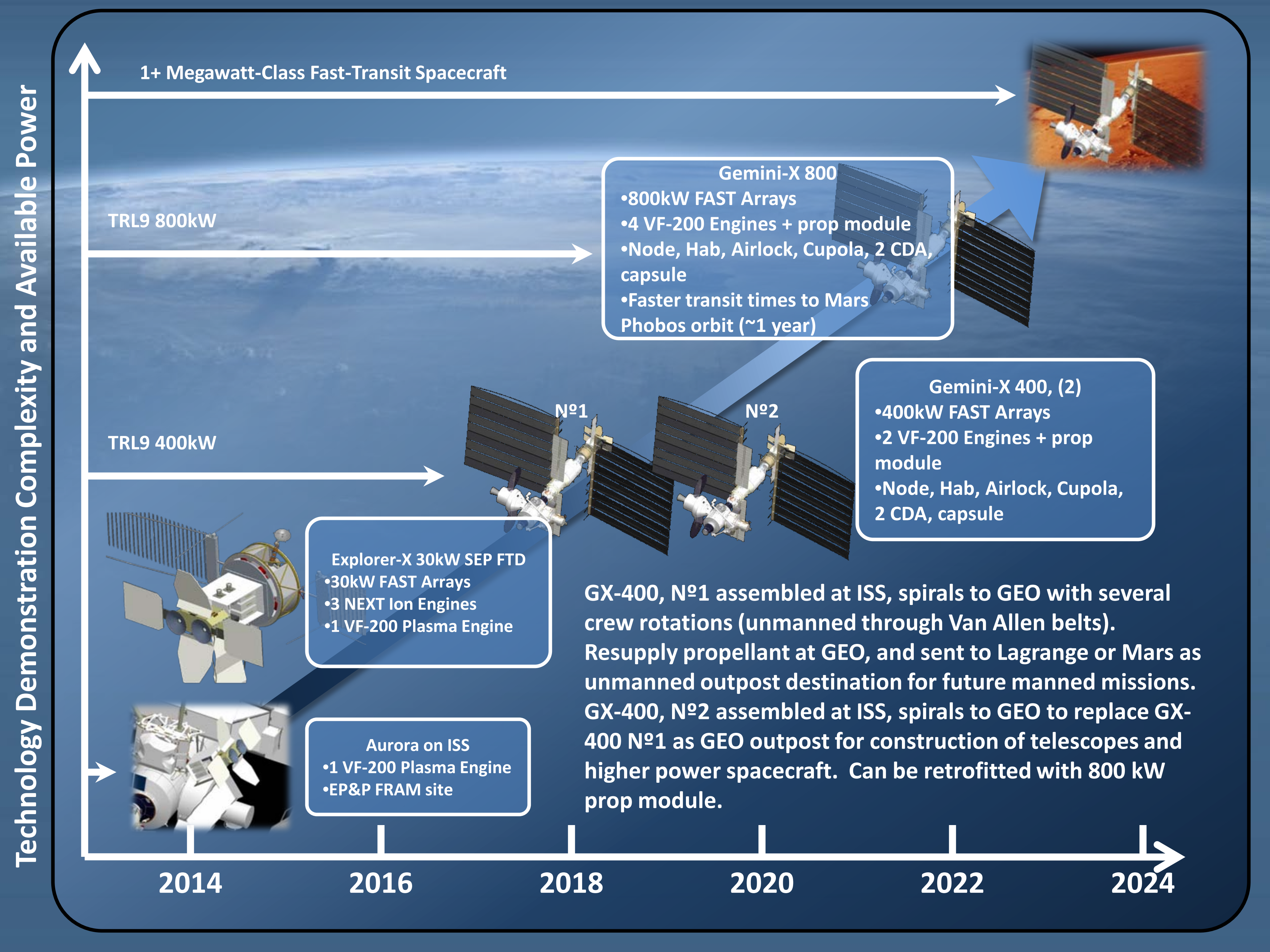
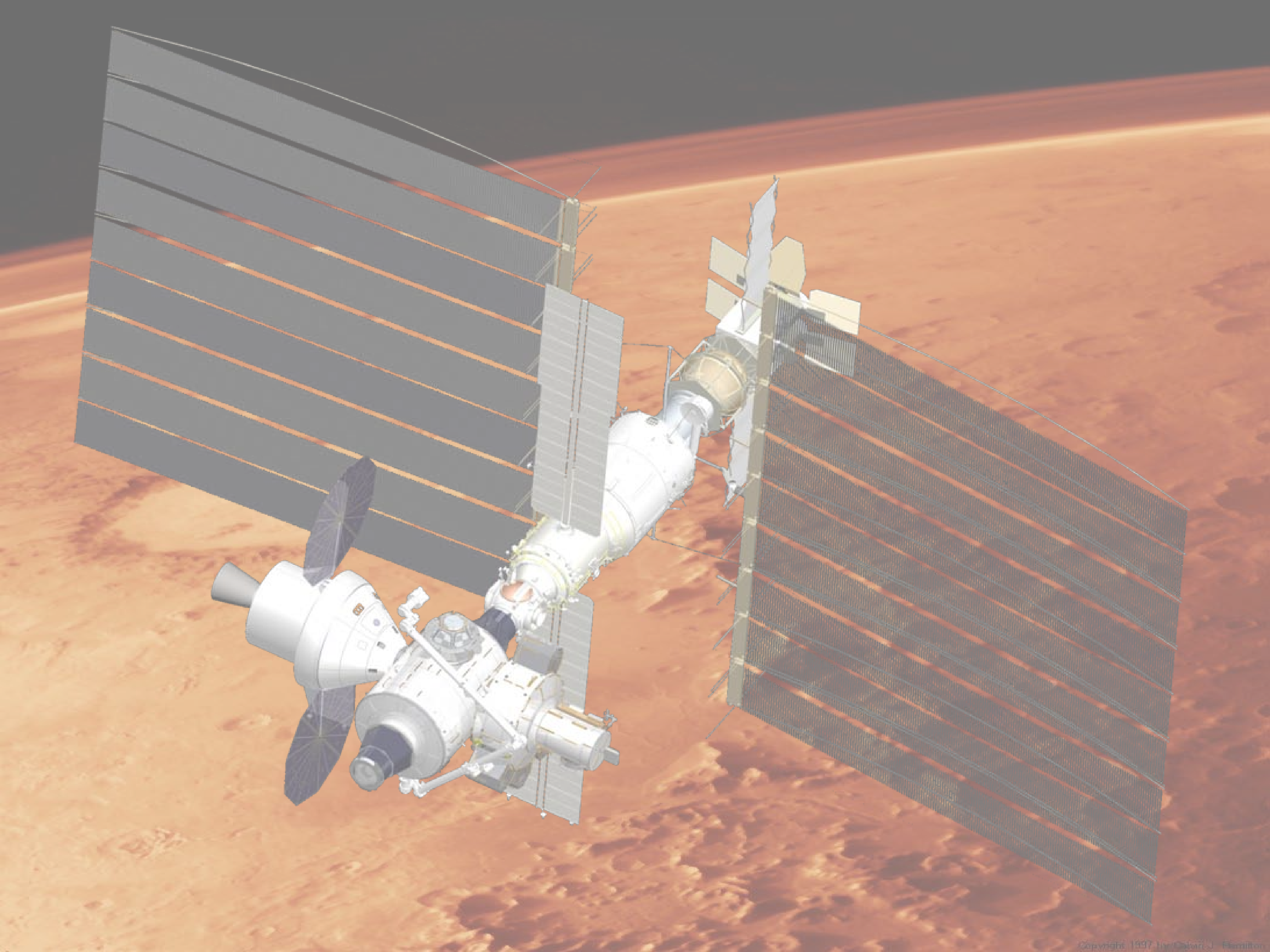

Technology Demonstration Complexity and Available Power
1+ Megawatt-Class Fast-Transit Spacecraft
TRL9 800kW
Gemini-X 800
•800kW FAST Arrays
•4 VF-200 Engines + prop module
•Node, Hab, Airlock, Cupola, 2 CDA, capsule
•Faster transit times to Mars Phobos orbit (~1 year)
TRL9 400kW
№1
№2
Gemini-X 400, (2)
•400kW FAST Arrays
•2 VF-200 Engines + prop module
•Node, Hab, Airlock, Cupola, 2 CDA, capsule
Explorer-X 30kW SEP FTD
•30kW FAST Arrays
•3 NEXT Ion Engines
•1 VF-200 Plasma Engine
GX-400, №1 assembled at ISS, spirals to GEO with several crew rotations (unmanned through Van Allen belts). Resupply propellant at GEO, and sent to Lagrange or Mars as unmanned outpost destination for future manned missions. GX-400, №2 assembled at ISS, spirals to GEO to replace GX-400 №1 as GEO outpost for construction of telescopes and higher power spacecraft. Can be retrofitted with 800 kW prop module.
Aurora on ISS
•1 VF-200 Plasma Engine
•EP&P FRAM site
2014
2016
2018
2020
2022
2024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